

B-1 Systems Group

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Using Airworthiness Criteria to Clarify and Communicate Requirements



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Overview

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- **Background**
- **Problem Discovery**
- **New Process**
- **Application**
- **Progress to date**



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Background

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- **Vertical Situation Display Upgrade**
 - Driven by Diminishing Manufacturing Sources & Material Shortages (DMSMS)
 - Replaces analog flight instruments with single media glass display
 - Adds second display at each station for situational awareness
- **Solution: Flight Display Subsystem**
 - Requirements derived from Weapon System Spec, Aircraft PIDS, and individual instrument CI specs
 - New requirements because of single media display
 - Comply with airworthiness and OSS&E policies



Flight Display Subsystem Overview

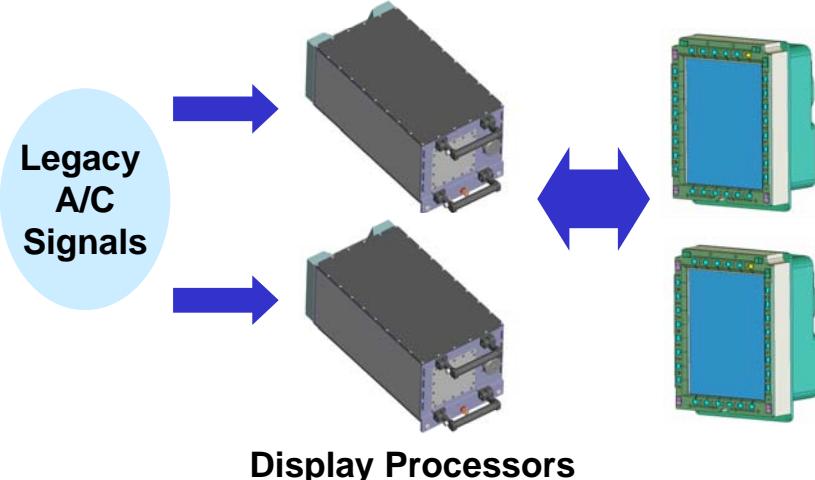


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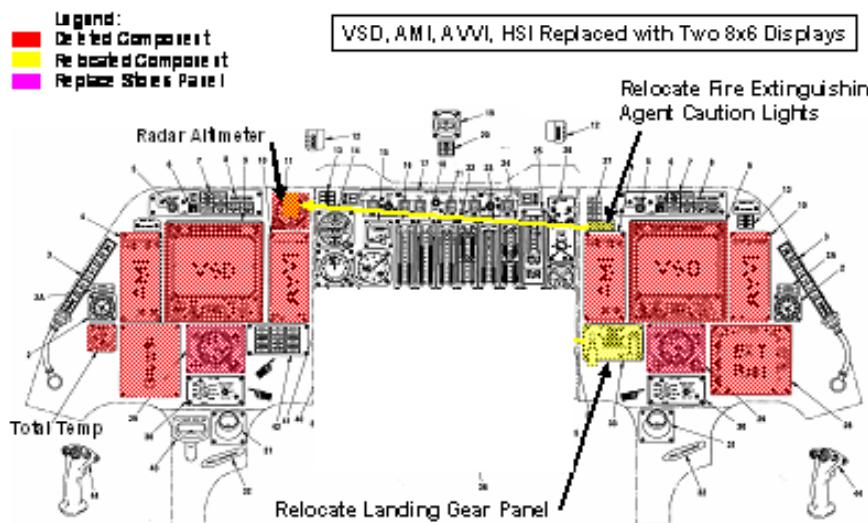
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- Replace and rehost legacy VSD and other analog instruments with full-color displays
- Resolves equipment obsolescence issues
- Displays will be used to improve pilot situational awareness (e.g., maps and datalinks) provided by future software upgrades
- Adds modern processing for growth
- Modification impacts
 - Pilot and copilot instrument panels
 - Primary flight instruments and displays
 - Diagnostics and power management

Modern Avionics Architecture



Legacy B-1B Pilot Instrument Panel Impacts



New Cockpit Instrument Layout (center not shown)





Airworthiness Policy



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- **AFPD 62-6, USAF Aircraft Airworthiness Certification**
 - MIL-HDBK-516, Airworthiness Certification Criteria
 - PEO Policy for Systems Engineering
- **AFPD 63-12, Assurance of Operational Safety, Suitability and Effectiveness**
 - AFI 63-1201, Life Cycle Engineering
 - MIL-HDBK-514, OSS&E for the Aeronautical Enterprise

Criterion	Standard	Compliance	DoD/MIL documents	FAA documents
Verify that the design criteria, including requirements and rules, adequately address safety for mission usage, full permissible flight envelope, duty cycle, interfaces, induced and natural environment, inspection capability, and maintenance philosophy	Allocated high level mission and safety requirements down through the design hierarchy are defined. Allocated design criteria for all system elements and components result in required levels of safety throughout the defined operational flight envelope, usage, and life	Process documentation describes requirements allocation and design criteria definition. Traceability is shown among requirements, design solutions, and verification analyses and tests. Adequacy of design criteria to meet top level safety & airworthiness requirements is substantiated	Appropriate design criteria paragraphs of JSSG-2000, 2001, 2005, 2006, 2007, 2008, 2009, 2010, and others	14CFR references: 23.21-23.3, 25.21-25.33



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Legacy Process

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- **Contract development - engineering effort proposed**
 - Teaming On ProposalS process
Note: Airworthiness not considered when selecting deliverable data
- **Contract execution**
 - Included design reviews, TRR, FFTRR, flight test, configuration audits in the scope of work
- **Airworthiness certification**
 - Airworthiness determined based on standard requirements and design artifacts generated during execution
 - **Modification Airworthiness Certification Criteria** developed during/after developmental flight test (DT&E)
 - Just-in-time certification for FDE



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Problem Discovery

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- Sep 05 – risk reduction software review
- Oct 05 – received VSDU proposal
 - No mention of Airworthiness in RFP or SOW
- Neither adequately addressed requirement to meet 10^{-6} probability of catastrophic hazard (System Spec requirement)
- Low confidence that FDSS would be airworthy



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Immediate Actions

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- Used MIL-HDBK-516B to determine additional criteria applicable to VSDU
 - Identified 42 additional applicable criteria
 - Drove new design and testing requirements
- Joint discussions to tailor standards and compliance
 - Documented agreed-to expectations to meet compliance criteria
 - Outside experts to review criteria
 - SME from ASC/EN participated in discussions



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Long Term Actions



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- **Reviewed process for root cause**
 - Identified that airworthiness not considered upfront
- **Recommended change to proposal process**
 - Include MACC as one document to be written in Joint Document Writing (Block 2 of TOPS)
- **Updated TOPS process documentation**
 - Updated process guide issued Jun 06



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TOPS Process

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- **Teaming on Proposals is B-1 process to jointly develop proposals**
 - 6 steps from Requirements Identification to Contract Award
 - Each step has specific products and exit criteria
- **Joint Document writing is second step**
 - *E.g.,* SOW, IMP/IMS, ground rules and assumptions, Program Schedule, MACC, CDRL, Specifications
- **TOPS Process revised in Jun 06 to include MACC development in Joint Document writing**



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MACC Development



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- **Joint effort between contractor and USAF**
 - Program office personnel
 - Contractor personnel
 - Subject matter experts
- **Discuss and understand scope of change**
 - Baselines everyone and exposes underlying assumptions
- **Identify applicable criteria and sections**
- **Identify Contractor and Government OPR**



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MACC Development (cont.)



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- **Discuss and agree to standards, compliance and verification methodology**
 - Tailored standards from MIL-HDBK-516B
 - Verification Methodology and location of verification
 - Evidence of compliance
- **Document impacts and assumptions for each criterion**
- **Document agreements in spreadsheet**
 - Extract pertinent data into MACC format



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Application

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- **Applicable criteria identified during Joint Document Writing**
- **Criteria examined for additional (derived) requirements**
 - *E.g., monitor to detect frozen displays and cross compare of data (hazardously misleading information)*
- **Evidence of compliance examined for additional data items**
 - *E.g., Failure modes effect and criticality analysis, failure modes effects test report*



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Application (Cont)



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- Requirements incorporated into high level specifications
 - System spec, PIDS, subsystem spec, as appropriate
 - Allocated to lower level specs
- Method of compliance captured in spec verification section
 - Aids in planning integration and test from CSC test to flight test
- Compliance verified as part of integration and test



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Benefits

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- **Another vehicle for discussions**
 - Discussion of standards and compliance leads to more complete requirements
 - Joint agreement on standards and compliance enhances understanding of requirements
 - Technical discussions bring both parties' assumptions to light
- **Aids in planning system validation**
 - Identifies more complete set of test events
 - Identifies and scopes required analyses



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Benefits (Cont)

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- **Results in higher quality proposals**
 - More complete requirements
 - Better understanding of scope of tasks
 - Most costs identified in proposal phase
 - More schedule realism
- **No new artifacts required**
 - Only expanded content



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Progress to Date

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- **Revisited specifications in light of airworthiness criteria**
 - System Requirements Review delayed
 - All other reviews held on schedule
 - Good allocation of requirements to lower tier specifications
- **System design proceeding**
 - Confident that system will meet 10^{-6} probability requirement
 - ASC/EN team will review design prior to first flight



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Other Efforts

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- **Process applied retroactively to Radar Reliability and Maintainability Improvement Program**
 - Software qualification test and flight test approaches were adequate
 - No new artifacts required
 - Hardware qualification approach needed to be readdressed



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Other Efforts (Cont)

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- **Inertial Navigation System**
 - Process clarified test approach
 - Better insight into logistics requirements



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Summary

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- **Jointly developing MACC during proposal preparation improves communication**
- **Better understanding of technical requirements**
- **Aids in planning system validation**
- **Higher fidelity cost and schedule**